# Chapter 2
# Applications of Biomechanics Analysis in Dance

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## ABSTRACT

*The field of sports biomechanics aims to improve performance and decrease injury rates in athletes. Although first developed thinking of athletes, sports biomechanics analysis was expanded to the dance field due to the similarities between athletes and dancers, including high workload, high injuries incidence, and the constant seeking of performance improvements. For the past few decades, a field focused only on dancers, thus called "dance biomechanics," has used sports biomechanics literature and produced its own knowledge analysing different dancers and many types of dance. Many questions have been made about dance, and some of those have been addressed by dance biomechanics. This chapter will explain how science has tried to answer many of them.*

## INTRODUCTION

Almost fifty years ago, Miller et al. (1975) wrote an article about athletic injuries in ballet dancers. According to them, "…the ability to leap in the air and complete two or three 360º turns and land on one foot in a perfect arabesque facing three-quarters front to the audience, plus or minus 5º, is similar if not more exacting than the gross movements of football, basketball and the like" (Miller, Schneider, Bronson, & McLain, 1975).

DOI: 10.4018/978-1-7998-4261-3.ch002

Because of the high demands of dance, professional dancers are often compared to elite athletes in several aspects. While accounting for the differences between forms of dance and between dance and different athletics activities, some of the main aspects of professional dance and elite sport are significant (Koutedakis & Jamurtas, 2004). Due to these similarities, professional dancers are often considered artists and athletes (Allen & Wyon, 2008). Elite athletes are highly skilled individuals who are engaged in competitive sports performance. They train repetitively for several hours every day, preparing for the few single performances that count during competitions. Likewise, professional dancers spend up to one and a half hours in classes and eight hours of rehearsing every day (Micheli et al., 2005; Weiss, Shah, Burchette, & Science, 2008). Both elite athletes and professional dancers are continually seeking performance improvements, and both suffer a high number of injuries throughout their careers (Koutedakis & Jamurtas, 2004). At the level of a professional dancer or an elite athlete, small changes are only obtained with much work. They are already performing at the top level, but they aim to perform at an even higher level. Professional dancers aim to dance perfectly with no apparent effort, with more precise lines, higher amplitude and controlled movements. The small details may be the difference in performing better and even in reducing injury risks.

Many questions are raised continuously about a dancer's technique, training, and equipment. When is a dance student ready to dance *en pointe*? How often are professional dancers injured? What is causing injuries in dance? How is a pirouette performed? Can turnout be enhanced? What are dancers achieving from training? Many of these questions related to dancers' performance may be addressed by biomechanics. After an extensive search of dance biomechanics literature, some of the main areas in which sports science can aid dance have been identified. In the following pages, some of the questions that may be helped by biomechanics will be addressed.

## KINEMATICS - HOW CAN ONE APPEAR TO FLOAT IN THE *GRAND JETÉ*?

As detailed in the previous chapter, kinematics analysis aims to understand the motion without regard to the forces that caused it. Kinematics studies may be as simple as a qualitative analysis of a movement recorded with a phone and as complex as quantitative analysis of a motion in a three-dimensional reconstruction of several cameras' recording (Figure 1 shows an example of kinematic data collection using 3-D cameras and reflexive markers). The first thing to learn when studying kinematics is what variables may be obtained from the data. For studying motion, one must learn what is moving and where it is at each instant. After learning the positions of a moving body, it is possible to calculate the velocity of its movement, and when the velocity is known, acceleration may be calculated. The motion of the human body may be represented by a single point, corresponding to the centre of a mass. The centre of mass, also known as the centre of gravity, represents the entire body's movement.

Using one digital camera and attaching a marker to the trunk of the dancer at the approximate height of the centre of mass, the movement of the body during the *grand jeté* was filmed for analysis (Dias et al., 2018). Filming the *grand jeté* in the sagittal plane (the right or left side view) of the dancer, the centre of mass movement follows a parabolic arch. The *grand jeté* is one of the most captivating jumps in ballet because it produces an illusion that the dancer is floating in the air. Nevertheless, when only the centre of mass is observed, the illusion does not occur.